# National Advisory Committee for Aeronautics

# Research Abstracts

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## CURRENT NACA REPORTS

NACA Rept. 1108

EXPERIMENTAL AERODYNAMIC DERIVATIVES OF A SINUSOIDALLY OSCILLATING AIRFOIL IN TWO-DIMENSIONAL FLOW. Robert L. Halfman, Massachusetts Institute of Technology. 1952. ii, 44p. diagrs., photo., 19 tabs. (NACA Rept. 1108. Formerly TN 2465)

Experimental measurements of the aerodynamic reactions on a symmetrical airfoil oscillating harmonically in a two-dimensional flow are presented and analyzed. Harmonic motions include pure pitch and pure translation, for several amplitudes and superimposed on an initial angle of attack, as well as combined pitch and translation. Considerable consistent data for pure pitch were obtained from a search of available reference material, and several definite Reynolds number effects are evident.

NACA Rept. 1120

RELATIVE IMPORTANCE OF VARIOUS SOURCES OF DEFECT-PRODUCING HYDROGEN INTRODUCED INTO STEEL DURING APPLICATION OF VITREOUS COATINGS. Dwight G. Moore, Mary A. Mason and William N. Harrison. 1953. 12p. photos., diagrs., 5 tabs. (NACA Rept. 1120. Formerly TN 2617)

The purpose of this investigation was to study and to determine experimentally the relative importance of various sources of defect-producing hydrogen introduced into steel during the application of vitreous-type ceramic coatings. Under the conditions investigated, the principal source of defect-producing hydrogen was the dissolved water present in the enamel frit of the coating. Acid pickling, milling water, chemically combined water in the clay, and quenching water were all minor sources. Test results indicate that fishscaling, reboil, and possibly primary boil may be eliminated by using a coating prepared with a water-free frit.

NACA TN 2978

AN APPROXIMATE METHOD OF CALCULATING THE DEFORMATIONS OF WINGS HAVING SWEPT, M OR W, Λ, AND SWEPT-TIP PLAN FORMS. George W. Zender and William A. Brooks, Jr. October 1953. 28p. diagrs., photo. (NACA TN 2978)

An approximate method of calculating the deformations of wings of uniform thickness having swept, M or W, Λ, and swept-tip plan forms is presented. The method employs an adjustment to the elementary beam theory to account for the effect of the triangular root portion of a swept wing on the deformation of the outboard section of the wing. It is shown that, for calculating angles of attack due to loading, the unmodified elementary theory alone suffices.

NACA TN 3010

COMPARISON OF EFFECTIVENESS OF CONVECTION-, TRANSPIRATION-, AND FILM-COOLING METHODS WITH AIR AS COOLANT. E. R. G. Eckert and John N. B. Livingood. October 1953. 52p. diagrs. (NACA TN 3010)

Material necessary for a comparison of the cooling requirements of film and transpiration cooling with conventional convection cooling is presented. Both laminar and turbulent flow, with and without radiation, are considered for a flat plate. The superiority of transpiration cooling is clearly shown for both laminar and turbulent flow.

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NACA TN 3013

A NOTE ON SECONDARY FLOW IN ROTATING RADIAL CHANNELS. James J. Kramer and John D. Stanitz. October 1953. 33p. diagrs. (NACA TN 3013)

A general vector differential equation for the vorticity component parallel to a streamline is derived for steady, nonviscous and incompressible flow in a rotating system. This equation is then simplified by restricting it to rotating radial channels and by making further simplifying assumptions. This simplified equation is used to solve for the secondary vorticity, the vorticity component parallel to the streamline, in three special cases involving different streamtube geometries; the results are presented in a series of figures. The secondary vorticity is shown to decrease with decreased absolute angular velocity of the fluid, decreased inlet total-pressure gradient, decreased length of relative flow path, and increased relative velocity.

NACA TN 3018

A THEORETICAL STUDY OF THE EFFECT OF FORWARD SPEED ON THE FREE-SPACE SOUND-PRESSURE FIELD AROUND PROPELLERS. I. E. Garrick and C. E. Watkins. October 1953. 39p. diagrs., tab. (NACA TN 3018)

The sound-pressure field due to thrust and torque of a propeller in flight at uniform subsonic speed is analyzed by use of a distribution of acoustic doublets located at the propeller disk. The results can be regarded as an extension of the work for the static

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propeller given by Gutin (NACA TM 1195) for the far pressure field and given by Hubbard and Regier (NACA Rep. 996) for the field near the tips of the rotating propeller. The extended formulas are used to calculate the sound field for a specific two-blade propeller operating at constant torque for various forward-speed Mach numbers.

NACA TN 3020

DETERMINATION OF BOUNDARY-LAYER TRANSITION REYNOLDS NUMBERS BY SURFACE-TEMPERATURE MEASUREMENT OF A $10^{\circ}$ CONE IN VARIOUS NACA SUPERSONIC WIND TUNNELS. Albert O. Ross. October 1953. 26p. diagrs., tab. (NACA TN 3020)

An investigation was conducted in the Ames and Lewis supersonic tunnels to determine transition Reynolds numbers on a $10^{\circ}$ cone at zero angle of attack. Measurements of surface temperature at known increments along the cone were made for the case of negligible heat transfer and negligible wind-tunnel pressure gradients. The trends of transition Reynolds number with stream Reynolds number and with Mach number are not consistent for the various tunnels. The inconsistencies are attributed to effects of free-stream turbulence, flow irregularities introduced by the compressor systems, and other air-stream disturbances.

NACA TN 3021

A METHOD OF DERIVING FREQUENCY-RESPONSE DATA FOR MOTION OF THE CENTER OF GRAVITY FROM DATA MEASURED ON AN AIRCRAFT AT LOCATIONS OTHER THAN THE CENTER OF GRAVITY. John M. Eggleston. October 1953. 25p. diagrs. (NACA TN 3021)

A method is given for deriving time-response and frequency-response data for angle of attack and normal acceleration of the center of gravity of an aircraft when these data are measured at locations on the aircraft other than the center of gravity and when the pitching velocity is not recorded. The method may be applied to aircraft in which limited recording channels and space limitations restrict the number and location of recording instruments. The application of this method is illustrated with data obtained from drop tests of a freely falling model.

NACA TN 3024

MAXIMUM EVAPORATION RATES OF WATER DROPLETS APPROACHING OBSTACLES IN THE ATMOSPHERE UNDER ICING CONDITIONS. Herman H. Lowell. October 1953. 56p. diagrs., 3 tabs. (NACA TN 3024)

Maximum possible evaporation rates of water droplets approaching obstacles in the atmosphere along stagnation lines or moving within intake ducts of airplanes under icing conditions were calculated for a wide variety of ambient conditions, flight Mach numbers, degrees of stagnation of the incident relative air stream, and droplet diameters. Droplet diameter, body size, and flight Mach number effects were found to predominate, whereas wide variation in ambient conditions had little effect on evaporative losses. It was concluded that little or no evaporative loss occurs from droplets approaching small obstacles such as liquid-water-content measurement cylinders, whereas losses may be as high as several percent in the case of larger obstacles such as wings, or 50 percent in the case of ducts at high ram pressure. Losses in ducts in general, however, will usually be about 10 to 20 percent.

NACA TN 3025

AN INVESTIGATION UTILIZING AN ELECTRICAL ANALOGUE OF CYCLIC DE-ICING OF HOLLOW STEEL PROPELLERS WITH INTERNAL ELECTRIC HEATERS. Carr B. Neel, Jr. October 1953. 31p. diagrs., photo., 3 tabs. (NACA TN 3025)

An analytical study, utilizing an electrical analogue, of the heat requirements for cyclic de-icing of hollow steel propellers fitted with two types of internal electric heaters showed the impracticability of using an internal tubular heater, and illustrated the advantages of employing an internal shoe-type heater to distribute the heat more evenly to the blade surface. The importance of minimizing the thermal inertia of the system was demonstrated, and the magnitude of reductions in the total energy requirement made possible through reductions in heating period was indicated.

NACA TN 3031

PRELIMINARY EXPERIMENTAL INVESTIGATION OF LOW-SPEED TURBULENT BOUNDARY LAYERS IN ADVERSE PRESSURE GRADIENTS. Virgil A. Sandborn. October 1953. 37p. diagrs., photos. (NACA TN 3031)

Measurements of velocity profiles and skin friction in subsonic turbulent boundary layers with adverse pressure gradients are presented. The skin friction was measured by using a local heat-transfer instrument and employing a calibrated relation between heat transfer and skin friction. The skin friction in an adverse pressure gradient was found to decrease steadily with distance to a value approaching zero for the region of separation. The measured values of skin friction were related to the form factor and momentum thickness of the measured velocity profiles substantially in accordance with the equation of Ludwieg and Tillmann. Momentum thickness $\theta$ and mean velocity-profile-form parameters H computed according to the semiempirical method of Maskell have been compared with the measured quantities. From the agreement it is concluded that the method (which exploits the Ludwieg-Tillman formula for skin friction) gives results, for the flows investigated, well within a range of engineering accuracy for the predictions of profile parameters, local skin friction, and the point of flow separation; required data for the calculation are the profile parameters at a starting point and the pressure distribution.

NACA TN 3033

APPLICATION OF AN ELECTRO-OPTICAL TWO-COLOR PYROMETER TO MEASUREMENT OF FLAME TEMPERATURE FOR LIQUID OXYGEN - HYDROCARBON PROPELLANT COMBINATION. M. F. Heidmann and R. J. Priem. October 1953. 39p. diagrs., photos. (NACA TN 3033)

The development of an electro-optical two-color pyrometer and its application to the measurement of temperature and emissivity in the exhaust gases of an open-tube combustor during normal and oscillatory combustion are described. Temperature variations up to 1000° R and emissivity variations of 10 to 1 were measured; the variations were sporadic and periodic during normal and oscillatory operation, respectively. The results of simultaneous measurements of sound intensity and temperature by the two-color method and by a microwave absorption technique are also presented.

NACA RM L53G20a

CHARTS FOR ESTIMATION OF THE PROFILE DRAG-LIFT RATIO OF A HELICOPTER ROTOR HAVING RECTANGULAR BLADES WITH -8° TWIST. F. B. Gustafson. October 1953. 18p. diagrs. (NACA RM L53G20a)

Theoretically derived charts are presented for prediction of profile drag-tift ratios of helicopter rotors having rectangular blades with -8° twist. Conditions for onset of blade-section stalling are shown in the charts.

NACA TM 1361

CONCERNING THE FLOW ON RING-SHAPED COWLINGS. PART XIII. THE INFLUENCE OF A PROJECTING HUB. (Ueber die Strömung an ringförmigen Verkleidungen. XIII. Mitteilung: Der Einfluss einer vorgezogenen Nabe). D. Küchemann. October 1953. 19p. diagrs. (NACA TM 1361. Trans. from Zentrale fur wissenschaftliches Berichtswesen ler Luftfahrtforschung, Berlin. UM 3144)

The influence of thickness and length of a hub projecting from an inlet opening was investigated on one of the two new classes of circular cowls reported in NACA TM 1360.

## BRITISH REPORTS

N-25316C*

Aeronautical Research Council (Gt. Brit.)
NOTE ON THE EFFECT OF VARIABLE WALL TEMPERATURE ON HEAT TRANSFER. H. B. Squire. (Addendum to ARC R &M 1986). 1953. 2p. tab. (ARC R & M 2753; ARC 13,475)

This report records the extension of the method given in R & M 1986 on the heat-transfer calculation for airfoils to the case of variable surface temperature.

N-26539*

Aeronautical Research Council (Gt. Brit.)
EXPERIMENTS ON CONICAL DIFFUSERS. H. B. Squire. 1953. 18p. diagrs., tab. (ARC R & M 2751; ARC 12,838. Formerly RAE Aero 2216; ARC 13,499; TP 320)

Measurements of the characteristics of conical diffusers of area ratio 4 between entry and exit and of total cone angle 4°, 5°, 6°, 8°, and 10° were made to determine the effect of Reynolds number on efficiency for uniform entry flow. A range of entry Reynolds number between $5 \times 10^4$ and $10^6$ was covered. The pressure distributions along the walls and the velocity distributions at the end of the conical sections were measured. Further measurements of velocity distribution were made with conical diffusers of area ratio 16 between entry and exit and with pipe flow at the entry, to determine the velocity distributions which finally develop.

N-26566*

Forest Products Research Lab. (Gt. Brit.)
TRAILS OF TIMBERS FOR PLYWOOD MANUFACTURE. SAPELE (ENTANDROPHRAGMA CYLINDRICUM-SPRAGUE) GOLD COAST. (40 POUNDS PER CUBIC FOOT AT 15 PER CENT MOISTURE CONTENT) PROGRESS REPORT TWENTY. July 1953. 13p. 6 tabs. (Forest Products Research Lab.)

Four logs of Sapele that had been stored under water from December 1951 - March 1953 were treated with steam and peeled into veneer. Characteristics of the green veneer are given. The veneer was dried and cut into squares and glued together. Different treatment was given several lots. Results for each are given.

N-26651*

Royal Aircraft Establishment (Gt. Brit.)
TENSOR TRANSFORMATIONS FOR DESCRIBING SUCCESSIVE CHANGES IN THE ATTITUDE OF AN AIRCRAFT. E. H. Bateman. July 1953. 11p. (RAE Tech. Note Structures 121)

The methods of elementary vector and tensor analysis are applied to the problem of finding the attitude of an aircraft after successive applications of roll, pitch or yaw, or of rotations about any axes. General transformations are tabulated for the six second order combinations of roll, pitch, and yaw; and examples are given of a third order and a fifth order combination.

N-26653*

Royal Aircraft Establishment (Gt. Brit.)
SOME NOTES ON IRREVERSIBLE MACHINES. D. Rendel and J. Rudman. May 1953. 27p. diagrs., photo., tab. (RAE Tech. Note Mech. Eng. 144)

A mathematical analysis has been made of the simple type of irreversible machine without lost motion in which the internal frictional forces can be expressed in terms of the external loading. The analysis emphasises that the most efficient type of machine would be one in which, when operating against an opposing load, the input force gradually releases a brake which holds the output load. A model machine of this type, which can theoretically be made over 50-percent efficient, has been tested and found to be usable and irreversible up to an efficiency of 80 percent. A description of this machine and the tests

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made on it is given in the appendix which may be read without reference to the main text. Other forms of irreversible machines are more generally surveyed and their probable defects pointed out.

N-26654*

Royal Aircraft Establishment (Gt. Brit.)
ESTIMATION OF THE FATIGUE LIFE OF A TRANSPORT AIRCRAFT. P. B. Walker. July 1953. 9p. (RAE Structures 149)

A simple formula is presented for the safe life of an aircraft under reasonably good operating conditions from the standpoint of wing fatigue. Gusts are treated as the main factor in determination of fatigue life, though other factors are allowed for as being secondary. Before the formula can be used a simple fatigue test is required on critical components, and repeated several times to establish variation of nominally identical specimens. The loading cycle for this test corresponds to a sequence of up and down gusts of 8 ft/sec equivalent velocity. The life obtained is termed the "Standard Life" and corresponds to normal operating conditions on European Air Lines. Reservations in the use of the formula and correction for other operating conditions are discussed in general terms.

N-26656*

Royal Aircraft Establishment (Gt. Brit.)
A REVIEW OF HEAT RESISTANCE OF LAMINATED PLASTICS. W. W. Wright. June 1953. 10p. (RAE Tech. Note Chem. 1200)

The results of recent investigations of the heat resistance of laminated plastics are reviewed. Structural factors which influence thermal stability are listed and possible research developments indicated.

N-26657*

Royal Aircraft Establishment (Gt. Brit.)
LEAKAGE TESTS ON SOLID AND INFLATABLE RUBBER SEALS DESIGNED FOR USE IN WIND TUNNELS. D. I. T. P. Llewelyn-Davies and M. T. Caiger. January 1953. 24p. diagrs., tab. (RAE Tech. Note Aero 2219)

Tests have been made on two types of rubber seals designed for use in a variable pressure wind tunnel. A solid seal was designed which would satisfactorily seal gaps of up to 0.04 inch against pressure differences of $\pm 1$ atmosphere from atmospheric pressure and which required a minimum sealing force of 5 lb/inch run of seal. It is essential to keep to a minimum the number of joints in the seal and also it is important that the seal should be a loose fit in its groove. A minimum inflation pressure of 30 lb/sq in. gage was required to ensure satisfactory sealing when an inflatable seal was used to seal gaps of up to 0.128 inch against the same range of pressure differences. When sealing against pressures higher than atmospheric, the performance deteriorated rapidly due to the decrease of the effective seal pressure. Care was necessary to ensure that the seal did not roll out of its groove when the joint surfaces were slid apart.

# UNPUBLISHED PAPERS

N-9275*

Polytechnic Inst. of Brooklyn.
THE CALCULATION OF BOUNDARY LAYER STABILITY ON A FLAT SURFACE WITH HEAT TRANSFER USING AN INTEGRAL SOLUTION FOR THE MEAN FLOW. Martin Bloom. June 1951. 35p. diagrs., 2 tabs. (Polytechnic Inst. of Brooklyn. PIBAL Rept. 179)

The compressible laminar boundary layer over a flat surface with heat transfer at the surface, a unit Prandtl number, and a linear temperature viscosity relation, is considered. The one-parameter Karman Pohlhausen integral method is applied with a sixth-degree polynomial assumed for the velocity profile. The method is shown to predict accurately the velocity profile slopes and curvatures. It is also shown to give good stability estimates as compared with mathematically exact solutions. The procedure for estimating the minimum critical Reynolds number for instability is modified to extend its applicability somewhat for extreme amounts of heat transfer and high Mach numbers.

N-25342*

TEST APPARATUS FOR PRODUCTION OF THICK LAMINAR BOUNDARY LAYERS. (Versuchseinrichtung zur erzeugung dicker laminarschichten). K. Wieghardt. April 1953. 9p. diagrs. (Trans. from Zentrale fur wissenschaftliches Berichtswesen der Luftfahrtforschung, Berlin. UM 6610)

According to a suggestion by Professor Betz, very thick laminar layers may be produced for test purposes by blowing air out of a wing-nose model in an air flow as continuously as possible, for instance through a perforated sheet. Preliminary measurements on such a test apparatus resulted, for an approach flow of 20 m/s air velocity and 0.4 m starting distance, already in boundary layers several cm thick. Therewith one has a test arrangement with which the behavior of laminar boundary layers may be investigated experimentally in all details, without great expense.

N-25353*

BEHAVIOR OF THE AIRPLANE TIRE IN A LANDING WITH LARGE ANGLE OF SIDESLIP. (Das verhalten des flugzeugreifens bei der landung mit grossem schiebewinkel). E. Maier and W. Rheinwald. September 1953. 9p. photos. (Trans. from Aerodynamische Versuchsanstalt Gottingen E. V. Technische Berichte, v. 11, no. 8, 1944, p. 275-277.)

Landings with large angles of sideslip were simulated on the road on airplane wheels rigidly mounted in a test trailer. These landings show that the airplane tire is capable of withstanding these loads without being pulled off the wheel rim.